NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 11-93

LOW TEMPERATURE LIMIT EVALUATION OF MK 21 MOD 1 UBA USING REDUCED OVERBOTTOM (O/B) PRESSURE & EXTENDED GAS UMBILICAL LENGTH

LT L. J. CREPEAU

DECEMBER 1993

NAVY EXPERIMENTAL DIVING UNIT

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
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This report addressed three issues regarding the performance of the MK 21 MOD 1 UBA during unmanned testing. First, the influence of oral-nasal (O/N) mask seal integrity on work of breathing (WOB) levels was characterized. WOB levels were measured with the O/N mask in three configurations: 1) cemented directly to a test mannequin; 2) fitted to, but not cemented on the mannequin; and 3) removed from the UBA. Second, the low temperature operating limit, defined by the absence of ice formation in the UBA when operated to 60.65 msw (198 fsw), was established. Third, the performance of MK 21 MOD 1 UBAs, modified by Navy Experimental Diving Unit and Diving Systems International to reduce the likelihood of free-flow, was compared using 621 and 931 kPa (90 and 135 psi) overbottom (O/B) pressure air delivered through 91.44 m (300 ft), 9.5 mm (.375 in) ID umbilicals.

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Performance at the lower pressure was characterized because the MK III Light Weight Diving System can provide at least 621 kPa, but less than 931 kPa O/B air pressure. Performance of the NEDU modified regulator was also characterized using 621 and 931 kPa air, as well as a 931 kPa, 90/10 helium/oxygen (heliox) mix, delivered through 182.88 m umbilicals. Testing with air pressures of 621 and 931 kPa was conducted, respectively, to 20.22 and 60.65 msw (66 and 198 fsw); heliox testing was conducted to 90.97 msw (297 fsw). The following respiratory minute volumes (RMVs) were employed: 22.5, 40.0, 62.5, 75.0, and 90 liters per minute.

Higher WOB levels corresponded to the degree of O/N seal compromise. The intermediate O/N configuration was employed during subsequent testing.

Ice formation, causing minimal free-flow, occurred at -2.2°C (28°F); but not at 0°C (32°F); subsequent testing was conducted at this temperature.

Similar WOB levels were obtained from the NEDU and DSI modified regulators at all test depths, and reducing O/B pressure did not influence regulator performance. Reducing O/B air pressure, combined with increasing umbilical length, did not influence NEDU modified regulator WOB levels. Heliox WOB levels were lower than air levels at comparable depths, and remained similar to 90.97 msw.

With (O/B) pressure maintained at 931 kPa, NEDU recommends diving the MK 21 MOD 1 UBA using a 9.5 mm (.375 in) ID umbilical as long as 182.88m (600 ft) on air to 58.2 msw (190 fsw), and on heliox to 91.9 msw (300 fsw).

NEDU also recommends diving the MK 21 MOD 1 UBA no deeper than 18.4 msw (60 fsw) with an O/B air pressures between 621 and 931 kPa. Diving can be conducted to 18.4 msw using up to 182.88 m of 9.5 mm ID umbilical. NEDU strongly recommends against diving the MK 21 MOD 1 UBA deeper than 18.4 msw using O/B pressure lower than 931 kPa.

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INTRODUCTION

A previous report indicates the MK 21 MOD 1 underwater breathing apparatus (UBA) can suddenly begin free-flowing in a forceful, sustained manner. This condition can be triggered by an increase in over-bottom (O/B) pressure as modest as 103.4 kPa (15 psi), or by ascending 33 fsw[1].

A venturi device behind the diaphragm in the second stage regulator maintains reduced pressure while gas is moving through the inlet port, thereby reducing inspiratory effort. However, the gas flow past the second stage seat can become amplified by the venturi device into a sustained free-flow.

In order to alleviate this condition, NEDU modified the regulator body to reduce the likelihood of free-flow by drilling a 3.175 mm (.125 in) balancing port into the inlet tube of the regulator body[1] (Appendix A). This modification increases pressure behind the diaphragm, thereby reducing the propensity of the UBA to free-flow. This markedly reduced free-flow in NEDU modified regulators, with an incidental increase in work of breathing[2].

This modification alleviated a condition initially considered a bothersome inconvenience to the diver that carried minimal risk of inducing alveolar rupture and resulting arterial gas embolism (AGE). However, a more recent investigation[3] determined that the propensity for the MK 21 MOD 1 to free-flow represents a serious, probable health risk to working divers, and recommended this modification for all regulator bodies in the Fleet.

Recently, Diving Systems International, (DSI, Santa Barbara, CA) modified MK 21 regulator bodies in a manner similar to the NEDU modification. However, this modification differed from the NEDU modification as the inlet tube was drilled prior to welding together the regulator body components. The angle of the NEDU port into the inlet tube could not extend below the plane of the body's outer rim, approximately 50 degrees off the plane of the diaphragm mating surface. However, the DSI port angle is nearly parallel to the diaphragm mating surface.

As an ongoing study of improving the safety and performance of this regulator[4], this study was divided into three phases. The first phase determined the effect of the oral-nasal (O/N) mask seal on resistive work of breathing (WOB). The second phase determined the minimal temperature limits of this regulator without external heating, such as hot water delivered to the manifold block by a shroud. During the third phase, the WOB was characterized in various diving scenarios, using varied depths, breathing rates, overbottom (O/B) pressures, gas mixes, and umbilical lengths. Of particular concern is the performance of this UBA when the O/B pressure falls below 931 kPa (135 psi), an occurrence that is routinely encountered when the MK III Light Weight Diving System (LWDS) compressor system is used to supply air during MK 21 MOD 1 UBA diving operations.

METHODS

APPARATUS

Nine modified Navy 350 second stage test regulators (four NEDU and five DSI) were tested. Each regulator was tested in the same MK 21 MOD 1 helmet, which was mounted on a mannequin head designed to emulate a human face for evaluating work of breathing levels in UBAs. During initial testing, an unmodified regulator was installed in the helmet to determine the influence of O/N mask seal on WOB levels. The mannequin head was connected to a Riemers model 1500 variable volume breathing simulator. The mounted helmet was placed in a test ark situated in a hyperbaric chamber. Gas was supplied through 9.5 mm (.375 in) ID umbilicals whose entire length was submerged in the test ark.

PROCEDURE

Test regulators were set up and tested following standard EDF unmanned procedures[5]. During the first phase of the study, we set up an unmodified UBA on the mannequin head in one of three configurations: (1) with the O/N mask cemented directly to the mannequin, exaggerating the integrity of the O/N seal (SECURE SEAL); (2) with the O/N mask fitted to, but not cemented on the mannequin (NO SEAL), emulating the normal diving configuration; and (3) with the O/N mask removed entirely from the UBA (NO MASK). The second configuration was employed during subsequent WOB testing, described below.

During the second phase of the study, we sought to determine the minimum water temperature that this UBA could be operated in without ice formation and resulting free-flow.

During the third phase of the study, we tested the following factors to determine if they affect WOB levels in NEDU or DSI modified MK 21 UBAs: (1) the NEDU vs DSI modification; (2) reducing O/B pressure from 931 kPa to 621 kPa (135 psi to 90 psi); (3) using a 182.88 m (600 ft) vice 91.44 m (300 ft) umbilical at 931 kPa and 621 kPa; and (4) using a 90/10 HeO_2 (heliox) mix with the 182.88 m umbilical.

TEST PARAMETERS

The Riemers breathing simulator provided sinusoidal breathing loops. Throughout testing, we used the following respiratory minute volumes (RMVs): 22.5, 40.0, 62.5, 75.0, and 90 liters per minute (LPM).

During the first phase of the study, testing was conducted in -2.2°C (28°F) water at 10.11 msw (33 fsw).

During the second phase of the study, UBAs were initially tested in -2.2°C water. No ice formation was detected at the end of these runs. However, we consequently

discovered that the humidification chamber on the breathing machine had been dry, apparently since this study had begun. This apparatus normally provides moisture to the breathing medium to emulate a diver's exhaled breath, an important factor since it can cause regulator icing. This created an unrealistically dry condition in the breathing medium, so these data were discarded. After the humidification chamber was repaired, ice formation was routinely encountered at -2.2°C, precluding the completion of a single dive profile at that temperature. Thereafter, testing at that temperature was terminated. Phase two was then repeated in 0°C (32°F) water. Phase three was also conducted at this temperature.

During the third phase of the study, each regulator was tested at 10.11 to 90.97 msw (33 to 297 fsw) in 10.11 msw (1 ATA) increments, following the test parameters elucidated in Table 1.

TABLE 1

TEST PARAMETERS OF NEDU- AND DSI-MODIFIED MK 21 MOD 1 UBAs

REGULATOR SOURCE	UMBILICAL LENGTH (m/ft)	MAX TEST DEPTH (msw/fsw)	OVERBOTTOM PRESSURE (kPa/psi)	BREATHING MEDIUM
NEDU	91.44/300	20.22/66	621/90	AIR
NEDU	91.44/300	60.65/198	931/135	AIR
DSI	91.44/300	20.22/66	621/90	AIR
DSI	91.44/300	60.65/198	931/135	AIR
NEDU	182.88/600	20.22/66	621/90	AIR
NEDU	182.88/600	60.65/198	931/135	AIR
NEDU	182.88/600	90.97/297	931/135	HELIOX

RESULTS

Results of testing the O/N seal configuration are presented in Figure 1, and presented in raw form in Appendix B. Highest WOB levels were found in the NO MASK condition, and the lowest levels were found in the SECURE MASK condition; intermediate WOB levels were obtained in the NO SEAL condition. This suggests that higher WOB levels correspond to the degree of O/N seal compromise. The NO SEAL configuration was employed during the second and third phases of this study.

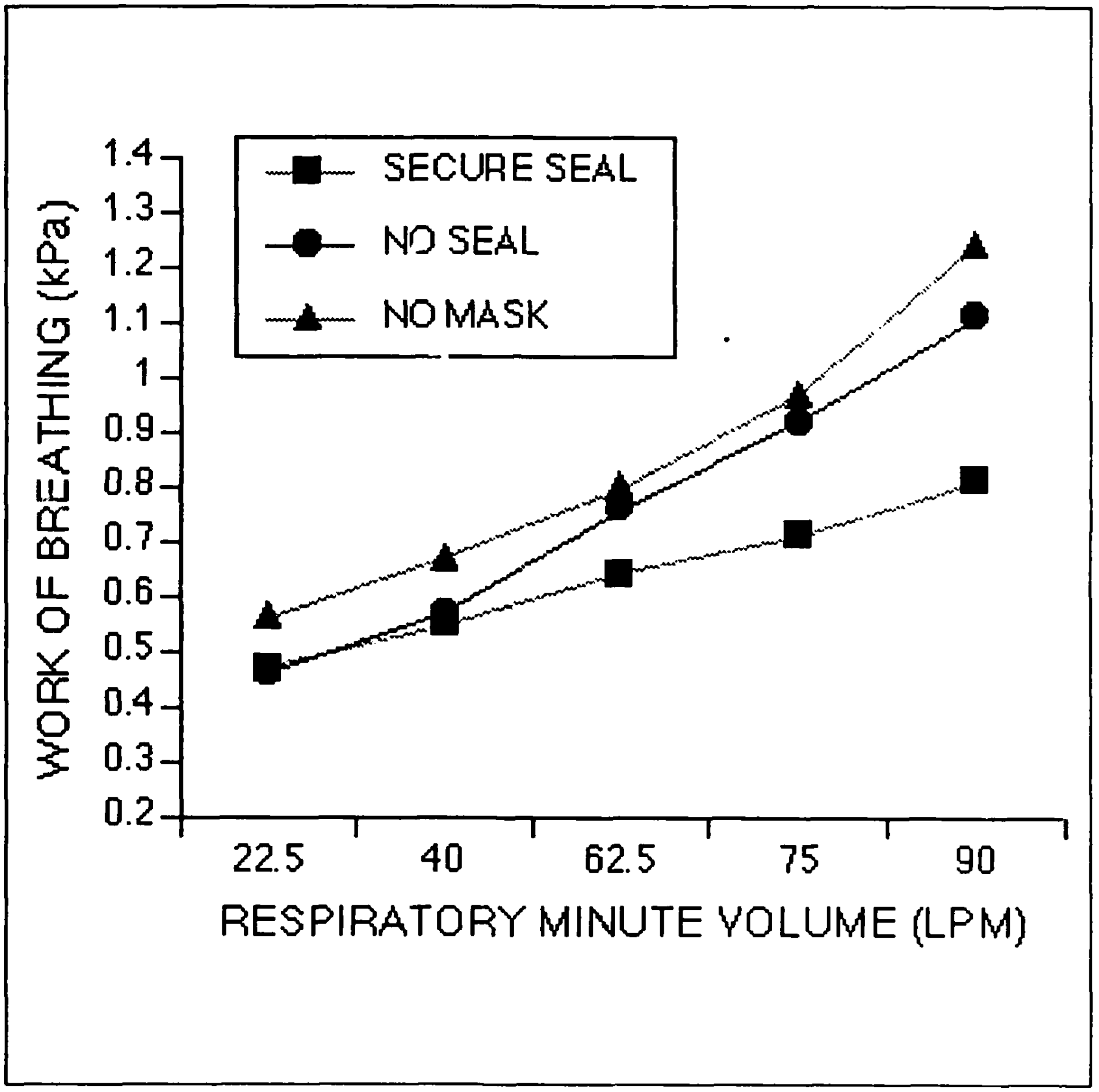

Figure 1. Influence of O/N mask seal on WOB

As mentioned earlier, regulator testing at -2.2°C (28°F) was terminated after ice formation and resulting free-flow in the second stage precluded WOB testing. The distribution of ice formation in the UBA is schematically presented in Figure 2. It is important to note that the free-flow obtained during these tests could be characterized as moderate hissing, and was not of the forceful, sustained kind encountered with an unmodified regulator when O/B pressure is abruptly increased or if a diver ascends in the water column without adjusting the dial-a-breath knob. All subsequent testing was conducted in 0°C (32°F) water; no ic formation was documented following these runs.

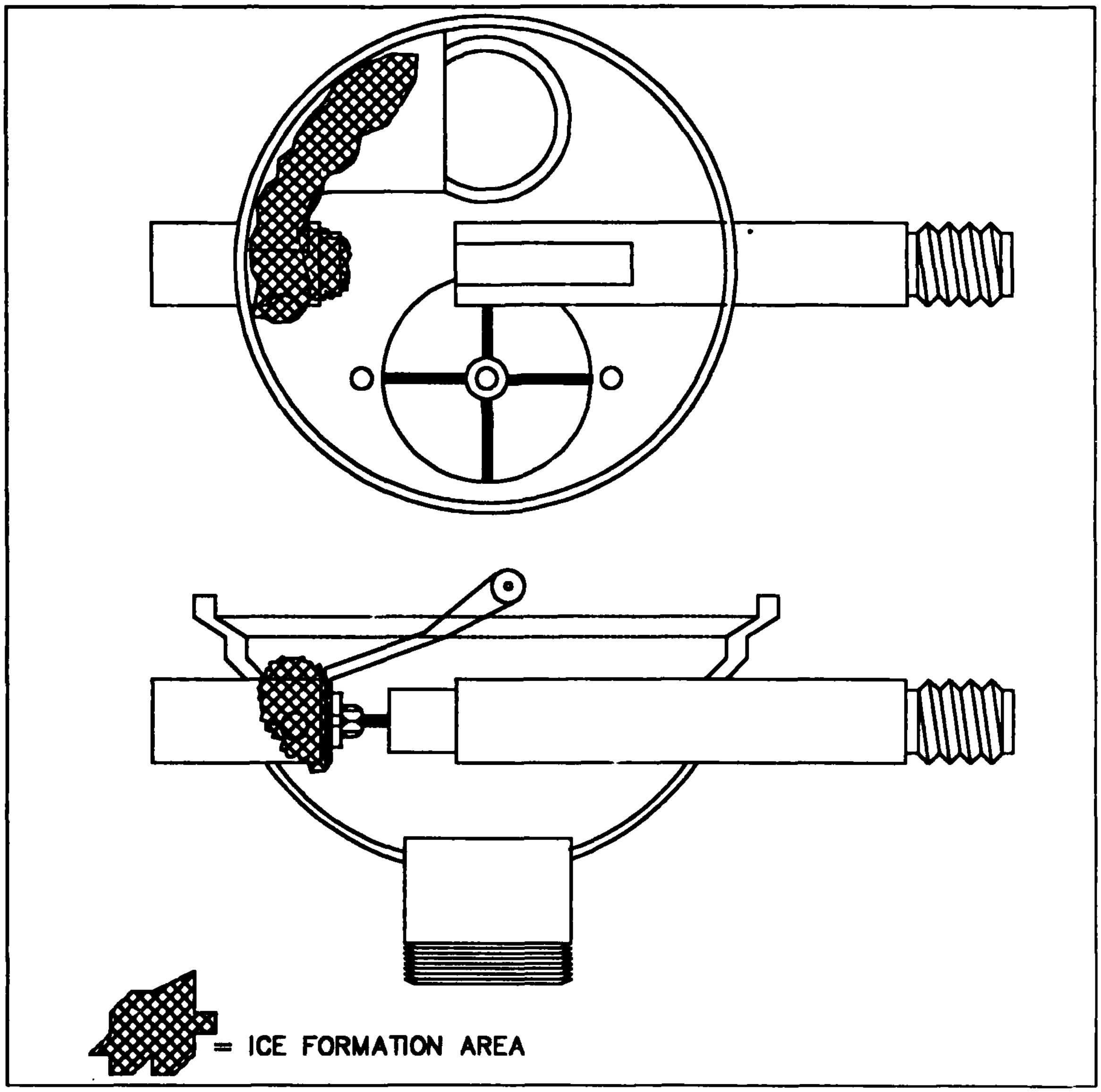

Figure 2. MK21 MOD 1 regulator ice formation

The raw data from all subsequent WOB testing are provided in Appendix C. Figure 3 shows WOB levels provided by the NEDU and DSI modified regulators during testing with a 91.44m (300 ft) umbilical, using 931 kPa (135 psi) O/B air. These results represent WOB levels averaged across all RMVs used, since the magnitude of increased WOB levels caused by higher RMVs was essentially identical between the two modifications. No differences between the two regulators were found at any depth.

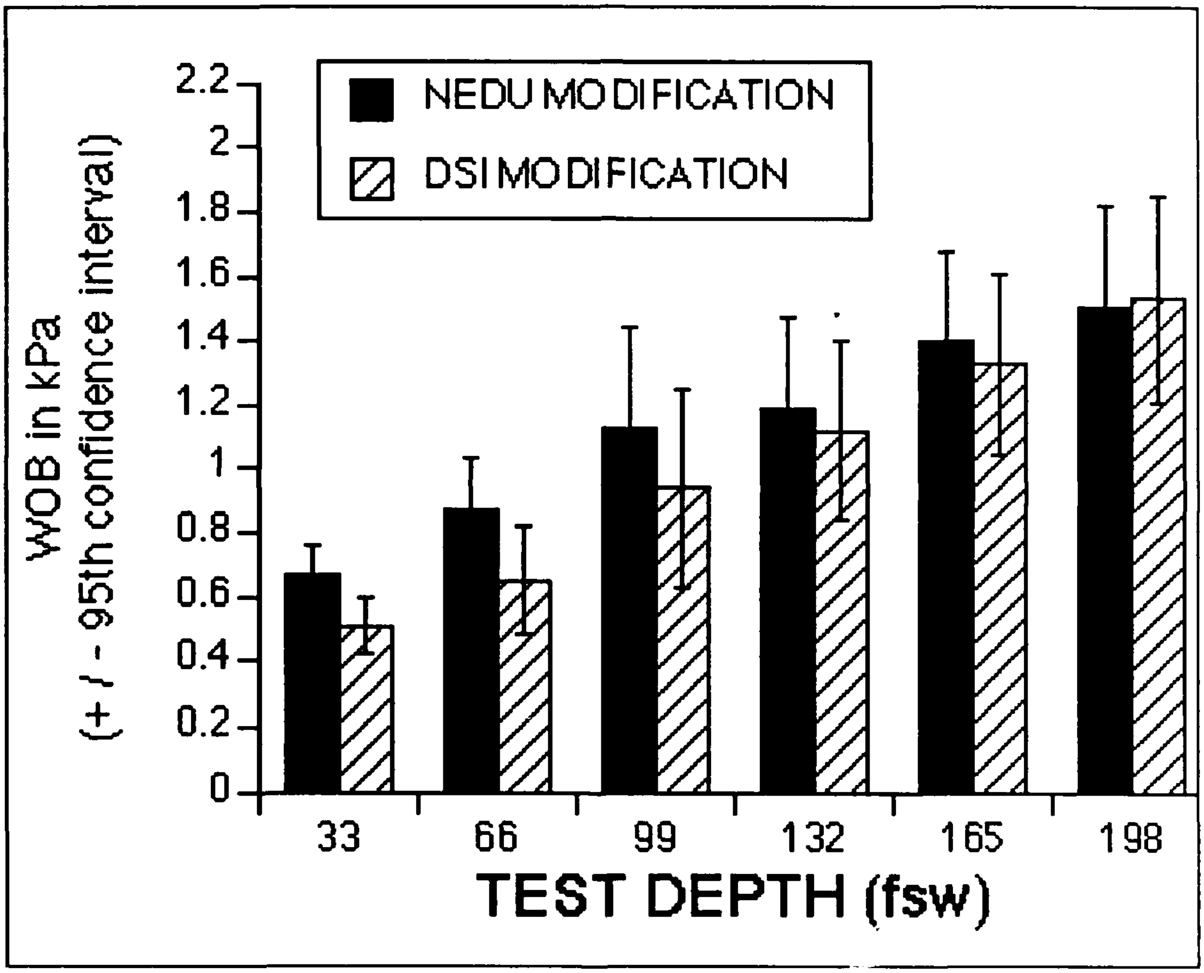

Figure 3. WOB levels obtained from 300 foot umbilical delivering 135 psi air

Figure 4 shows WOB levels provided by the NEDU and DSI modified regulators during testing with a 91.44 m umbilical, using 621 kPa (90 psi) and 931 kPa O/B air. At the two depths tested, reducing O/B pressure to 621 kPa did not reliably increase WOB levels over those obtained using 931 kPa O/B.

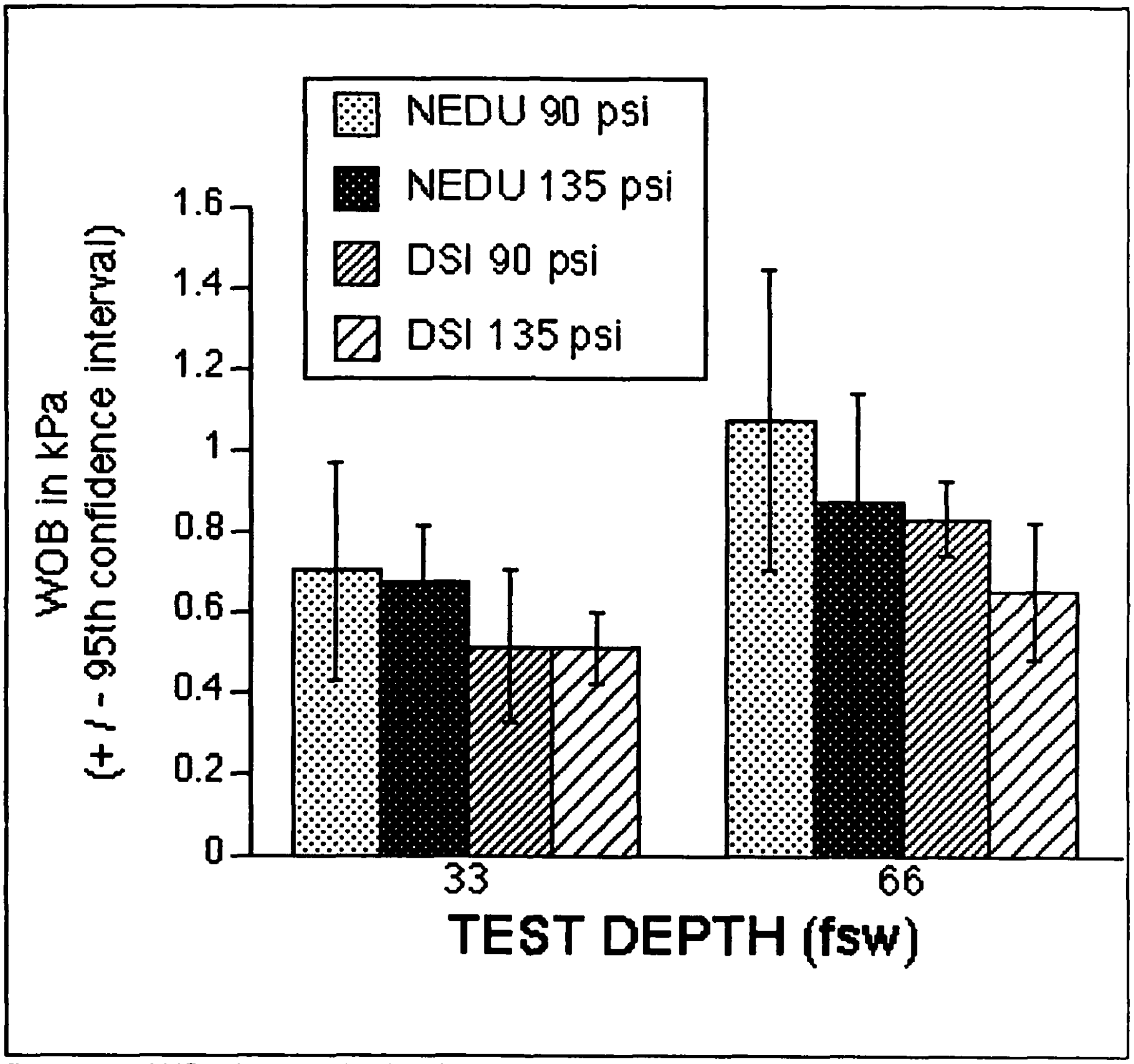

Figure 4. WOB levels obtained from 300 foot umbilical delivering air

Figure 5 compares WOB levels provided by the NEDU modified regulators during testing with a 91.44 m umbilical using 931 kPa O/B air to levels obtained using a 182.88 m (600 ft) umbilical using 621 and 931 kPa O/B air and 931 kPa O/B heliox. At all depths tested, increasing umbilical length to 182.88 m, in combination with reducing O/B air pressure to 621 kPa, did not influence WOB levels. In fact, acceptable[6] WOB levels were obtained from the NEDU modified regulator with 182.88 m (600 ft) umbilicals at 20.22 msw (66 fsw) using a 62.5 LPM RMV. In addition, heliox WOB levels were markedly lower than air levels, and heliox WOB levels were not elevated by increased test depth to 90.97 msw (297 fsw).

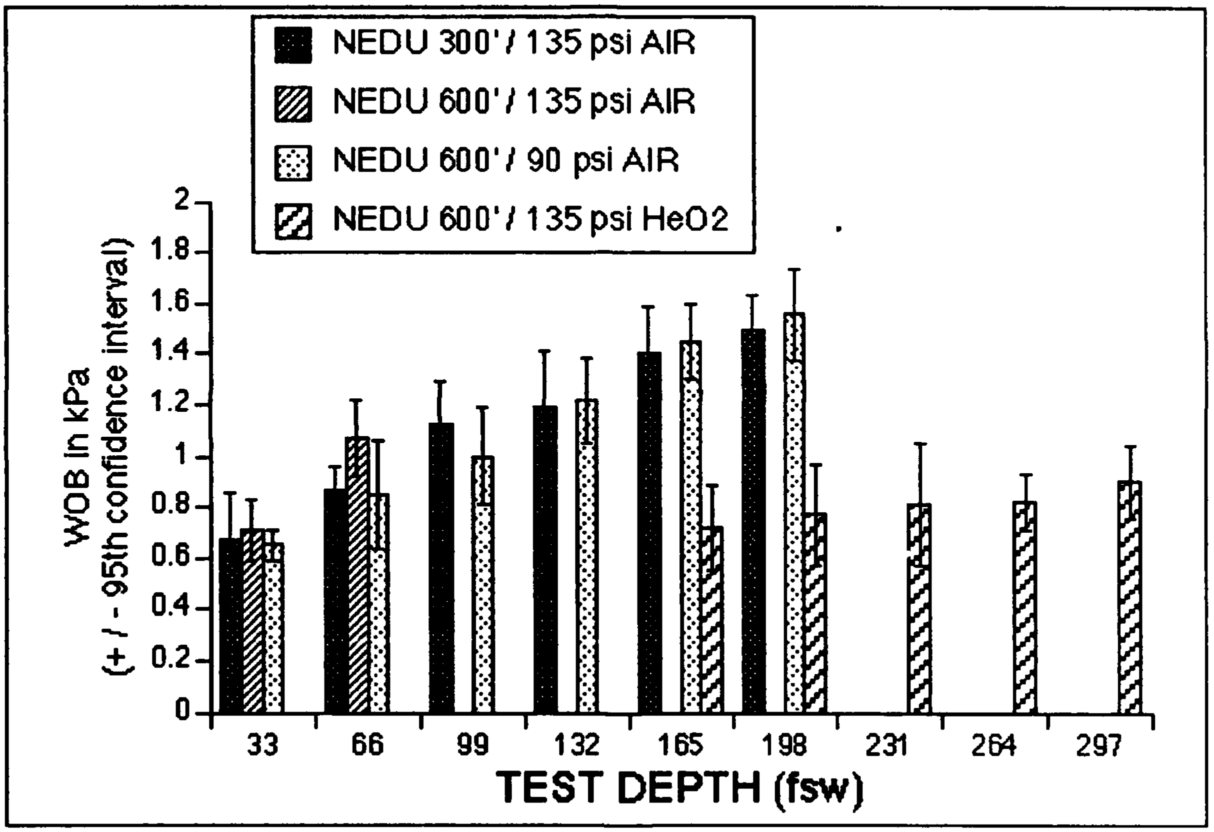

Figure 5. WOB levels obtained from 300 foot umbilical, compared to 600 foot umbilical levels

DISCUSSION

The results of this study indicate that the MK 21 MOD 1 UBA can be safely dived in 0°C (32°F) and warmer water without providing extraneous heat to the breathing apparatus. However, diving in colder water can cause an icing and resultant free-flow hazard if a hot water shroud is not used.

These results also suggest that this UBA can be safely dived with O/B air pressure maintained as low as 621 kPa (90 psi) using a 182.88 m (600 ft), 9.5 mm (.375 in) ID umbilical to 18.4 msw (60 fsw). Because WOB levels are elevated somewhat by the regulator modification[4], acceptable WOB levels can be expected as well from unmodified MK 21 MOD 1 UBAs, when dived within these parameters.

RECOMMENDATIONS

Ice formation routinely occurred in the MK 21 MOD 1 UBA regulator when tested in -2.2°C (28°F) water, using a breathing medium that was humidified as though from an exhaling diver. Because no regulator icing occurred at 0°C (32°F), NEDU recommends adopting 0°C as the cold water limit for this UBA, if it is to be dived without a hot water shroud.

Modifying the MK 21 MOD 1 UBA described in this study reduces the risk of a forceful, sustained free-flow, while only minimally increasing WOB levels. At the same time, similar work of breathing levels were conferred by NEDU and DSI modified UBAs. Therefore, NEDU recommends that DSI modified MK 21 MOD 1 regulator bodies be certified as an alternative source.

For those Navy units that employ air compressors capable of producing less than 931 kPa (135 psi) but at least 621 kPa (90 psi) O/B, such as the MK III Light Weight Diving System (LWDS), NEDU recommends diving the MK 21 MOD 1 UBA using a 9.5 mm (.375 in) ID umbilical as long as 182.88 m (600 ft) to 18.4 msw (60 fsw). At the same time, NEDU strongly recommends against diving the MK 21 MOD 1 UBA deeper than 18.4 msw using O/B pressure less than 931 kPa (135 psi), since the performance of this UBA using reduced O/B pressure at greater depths has not been characterized.

With O/B pressure maintained at 931 kPa, NEDU recommends diving the MK 21 MOD 1 UBA using a 9.5 mm (.375 in) ID umbilical as long as 182.88 m (600 ft) on air to 58.2 msw (190 fsw)[7], and on heliox to 91.9 msw (300 fsw)[8].

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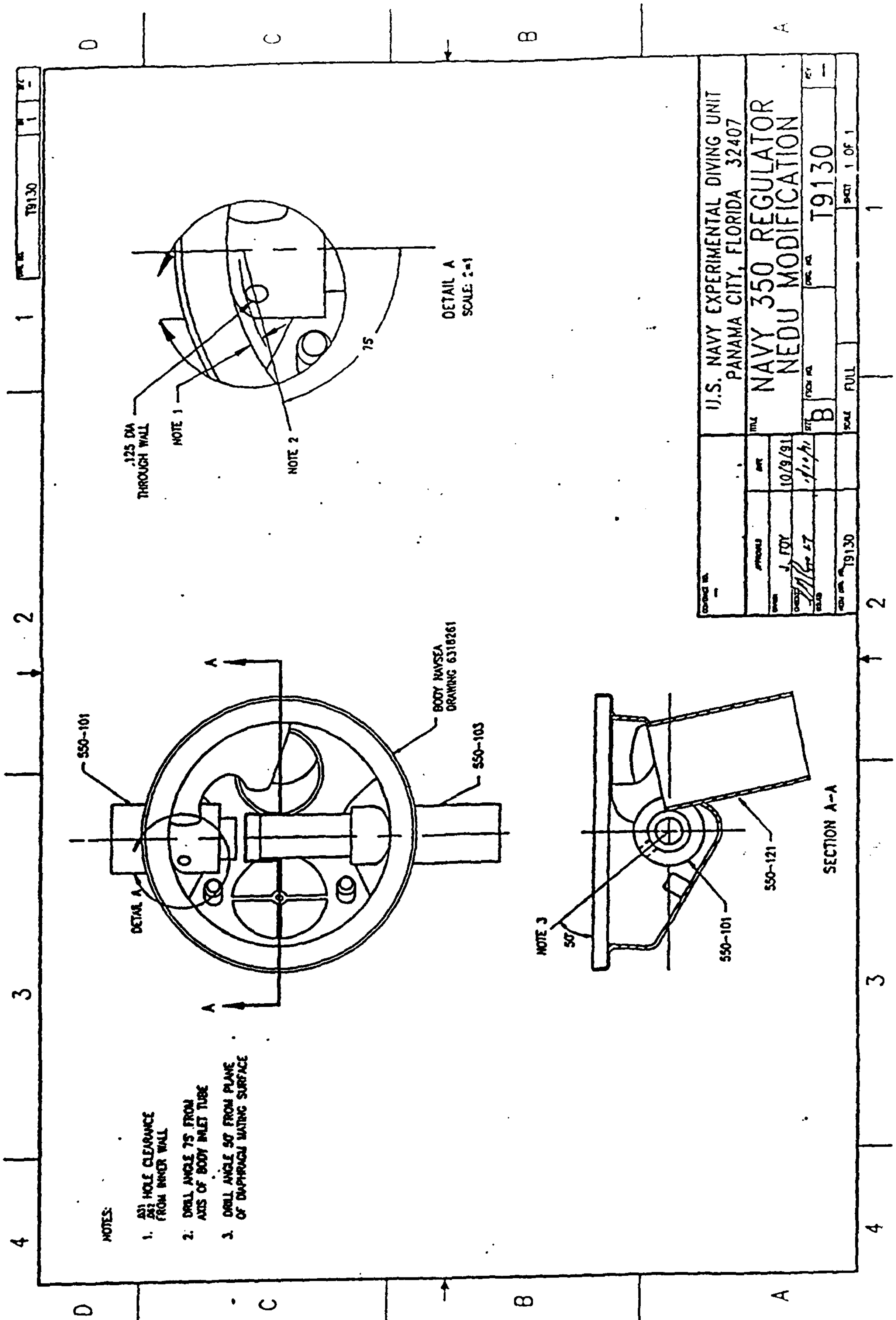
8. U. S. Navy Diving Manual, Vol. 2 (Mixed-Gas Diving), 0994-LP-001-9020, Rev. 3.

APPENDIX A


U.S. NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407
NAVY 350 REGULATOR
NEDU MODIFICATION
T9130
SCALE FULL
SHEET 1 OF 1
10/9/91
J. FOY
DETAIL A
SCALE: 2=1
.125 DIA
THROUGH WALL
NOTE 1
NOTE 2
NOTE 3
75
50
550-101
550-103
550-121
BODY NAVSEA
DRAWING 6318261
SECTION A-A
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NOTES:
1. .031 HOLE CLEARANCE
.062 FROM INNER WALL
2. DRILL ANGLE 75 FROM
AXIS OF BODY INLET TUBE
3. DRILL ANGLE 50 FROM PLANE
OF DIAPHRAGM MATING SURFACE

APPENDIX B

WORK OF BREATHING LEVELS IN kPa
OBTAINED USING VARIOUS ORAL-NASAL MASK SEAL CONFIGURATIONS

ORAL-NASAL MASK CONFIGURATION	RESPIRATORY MINUTE VOLUME (LPM)				
	22.5	40	62.5	75	90
SECURE SEAL	0.47	0.55	0.64	0.71	0.81
NO SEAL	0.46	0.57	0.76	0.92	1.11
NO MASK	0.56	0.67	0.80	0.97	1.24

APPENDIX C

WORK OF BREATHING LEVELS IN kPa

CONDITION 1: 91.44 m (300 ft), 9.5 mm (.375 in) ID umbilical, 931 kPa (135 psi) air:

REGULATOR	RESPIRATORY MINUTE VOLUME				
NEDU 1	22.5	40	62.5	75	90
10.11 msw (33 fsw)	0.34	0.47	0.52	0.59	0.78
20.22 msw (66 fsw)	0.47	0.58	0.81	1.09	1.32
30.32 msw (99 fsw)	0.71	0.87	1.21	1.52	1.94
40.43 msw (132 fsw)	0.50	0.70	1.09	1.49	2.26
50.54 msw (165 fsw)	0.51	0.74	1.35	2.01	2.66
60.65 msw (198 fsw)	0.54	0.87	1.80	2.43	N/A
NEDU 2					
10.11 msw (33 fsw)	0.46	0.50	0.62	0.66	0.71
20.22 msw (66 fsw)	0.51	0.66	0.90	1.10	1.13
30.32 msw (99 fsw)	0.62	0.77	1.10	1.32	1.60
40.43 msw (132 fsw)	0.56	0.82	1.20	1.49	2.01
50.54 msw (165 fsw)	0.59	0.92	1.38	1.77	2.38
60.65 msw (198 fsw)	0.62	0.93	1.57	2.10	2.67
NEDU 3					
10.11 msw (33 fsw)	0.63	0.71	0.78	0.80	0.93
20.22 msw (66 fsw)	0.58	0.69	0.80	0.86	1.18
30.32 msw (99 fsw)	0.63	0.80	1.03	1.14	1.51
40.43 msw (132 fsw)	0.50	0.67	1.02	1.10	1.74
50.54 msw (165 fsw)	0.58	0.73	1.05	1.57	2.22
60.65 msw (198 fsw)	0.61	0.76	1.38	1.89	2.52
NEDU 5					
10.11 msw (33 fsw)	0.54	0.66	0.76	0.89	0.98
20.22 msw (66 fsw)	0.58	0.74	1.00	1.13	1.33
30.32 msw (99 fsw)	0.64	0.84	1.22	1.41	1.66
40.43 msw (132 fsw)	0.64	0.93	1.37	1.64	2.11
50.54 msw (165 fsw)	0.65	0.98	1.51	1.93	2.48
60.65 msw (198 fsw)	0.70	1.06	1.75	2.24	N/A

DSI 1	22.5	40	62.5	75	90
10.11 msw (33 fsw)	0.36	0.43	0.49	0.54	0.62
20.22 msw (66 fsw)	0.36	0.43	0.54	0.61	0.63
30.32 msw (99 fsw)	0.66	0.73	0.87	0.89	1.84
40.43 msw (132 fsw)	0.51	0.55	0.84	1.18	1.82
50.54 msw (165 fsw)	0.45	0.51	0.98	1.42	2.14
60.65 msw (198 fsw)	0.40	0.50	1.25	1.83	2.45
DSI 2					
10.11 msw (33 fsw)	0.34	0.46	0.50	0.53	0.62
20.22 msw (66 fsw)	0.38	0.51	0.73	0.93	1.03
30.32 msw (99 fsw)	0.43	0.55	0.84	1.02	1.40
40.43 msw (132 fsw)	0.43	0.57	0.87	1.26	1.95
50.54 msw (165 fsw)	0.44	0.62	1.11	1.79	2.68
60.65 msw (198 fsw)	0.43	0.69	1.62	2.34	N/A
DSI 3					
10.11 msw (33 fsw)	0.35	0.40	0.39	0.41	0.58
20.22 msw (66 fsw)	0.39	0.43	0.50	0.55	0.60
30.32 msw (99 fsw)	0.38	0.42	0.50	0.55	1.16
40.43 msw (132 fsw)	0.42	0.48	0.69	1.11	1.92
50.54 msw (165 fsw)	0.38	0.49	0.81	1.60	2.47
60.65 msw (198 fsw)	0.44	0.60	1.41	2.35	3.08
DSI 4					
10.11 msw (33 fsw)	0.38	0.47	0.60	0.74	0.94
20.22 msw (66 fsw)	0.44	0.60	0.83	0.92	1.20
30.32 msw (99 fsw)	0.50	0.77	1.21	1.74	2.25
40.43 msw (132 fsw)	0.53	0.89	1.48	2.03	2.42
50.54 msw (165 fsw)	0.56	0.96	1.82	2.32	2.73
60.65 msw (198 fsw)	0.63	1.09	2.10	2.51	3.03
DSI 5					
10.11 msw (33 fsw)	0.33	0.47	0.57	0.62	0.70
20.22 msw (66 fsw)	0.37	0.53	0.72	0.89	1.08
30.32 msw (99 fsw)	0.46	0.66	0.90	1.16	1.52
40.43 msw (132 fsw)	0.51	0.73	1.17	1.54	2.08
50.54 msw (165 fsw)	0.51	0.79	1.40	1.87	2.38
60.65 msw (198 fsw)	0.59	0.97	1.83	2.19	2.64

CONDITION 2: 91.44 m (300 ft), 9.5 mm (.375 in) ID umbilical, 621 kPa (90 psi) air:

REGULATOR	RESPIRATORY MINUTE VOLUME				
NEDU 1	22.5	40	62.5	75	90
10.11 msw (33 fsw)	0.37	0.49	0.75	0.89	1.05
20.22 msw (66 fsw)	0.35	0.52	0.79	1.19	1.75
NEDU 2					
10.11 msw (33 fsw)	0.41	0.51	0.63	0.69	0.84
20.22 msw (66 fsw)	0.46	0.64	0.92	1.07	1.42
NEDU 5					
10.11 msw (33 fsw)	0.53	0.64	0.85	0.98	1.12
20.22 msw (66 fsw)	0.58	0.75	1.11	1.36	1.70
DSI 1					
10.11 msw (33 fsw)	0.29	0.33	0.40	0.42	0.41
20.22 msw (66 fsw)	0.28	0.32	0.50	0.66	1.15
DSI 2					
10.11 msw (33 fsw)	0.30	0.37	0.47	0.57	0.69
20.22 msw (66 fsw)	0.34	0.46	0.68	1.02	1.70
DSI 3					
10.11 msw (33 fsw)	0.28	0.37	0.47	0.53	0.62
20.22 msw (66 fsw)	0.35	0.40	0.61	0.70	1.29
DSI 4					
10.11 msw (33 fsw)	0.38	0.50	0.75	0.76	0.99
20.22 msw (66 fsw)	0.42	0.68	1.15	1.65	2.08
DSI 5					
10.11 msw (33 fsw)	0.30	0.42	0.55	0.66	0.81
20.22 msw (66 fsw)	0.34	0.49	0.75	0.99	1.48

CONDITION 3: 182.88 m (600 ft), 9.5 mm (.375 in) ID umbilical, 621 kPa (90 psi) air:

REGULATOR	RESPIRATORY MINUTE VOLUME				
NEDU 1	22.5	40	62.5	75	90
10.11 msw (33 fsw)	0.36	0.51	0.73	0.88	1.12
20.22 msw (66 fsw)	0.42	0.61	0.93	1.22	1.75
NEDU 2					
10.11 msw (33 fsw)	0.43	0.58	0.75	0.88	1.01
20.22 msw (66 fsw)	0.44	0.60	0.96	1.33	1.71
NEDU 3					
10.11 msw (33 fsw)	0.56	0.66	0.81	1.00	1.27
20.22 msw (66 fsw)	0.58	0.71	1.01	1.35	1.81
NEDU 4					
10.11 msw (33 fsw)	0.35	0.46	0.56	0.70	0.88
20.22 msw (66 fsw)	0.74	0.97	1.25	1.44	1.97
NEDU 5					
10.11 msw (33 fsw)	0.40	0.55	0.80	0.96	N/A
20.22 msw (66 fsw)	0.42	0.65	0.99	1.25	1.69

CONDITION 3: 182.88 m (600 ft), 9.5 mm (.375 in) ID umbilical, 931 kPa (135 psi) HeO_2:

REGULATOR	RESPIRATORY MINUTE VOLUME				
NEDU 1	22.5	40	62.5	75	90
50.54 msw (165 fsw)	0.39	0.51	0.64	0.69	0.79
60.65 msw (198 fsw)	0.45	0.62	0.75	0.82	0.98
70.76 msw (231 fsw)	0.41	0.55	0.71	0.80	1.03
80.87 msw (264 fsw)	0.46	0.61	0.77	0.90	1.19
90.98 msw (297 fsw)	0.49	0.65	0.84	0.98	1.38
NEDU 2					
50.54 msw (165 fsw)	0.33	0.48	0.65	0.72	0.85
60.65 msw (198 fsw)	0.30	0.43	0.59	0.69	0.92
70.76 msw (231 fsw)	0.31	0.47	0.65	0.81	1.09
80.87 msw (264 fsw)	0.32	0.47	0.69	0.89	1.25
90.98 msw (297 fsw)	0.34	0.51	0.77	1.00	1.37
NEDU 3					
50.54 msw (165 fsw)	0.66	0.79	0.92	1.01	1.15
60.65 msw (198 fsw)	0.65	0.81	0.95	1.10	1.31
70.76 msw (231 fsw)	0.77	0.94	1.13	1.28	1.54
80.87 msw (264 fsw)	0.52	0.69	0.89	1.05	1.36
90.98 msw (297 fsw)	0.62	0.84	1.06	1.30	1.55
NEDU 4					
50.54 msw (165 fsw)	0.43	0.56	0.66	0.74	0.90
60.65 msw (198 fsw)	0.40	0.53	0.66	0.76	0.94
70.76 msw (231 fsw)	0.38	0.53	0.68	0.84	1.08
80.87 msw (264 fsw)	0.41	0.54	0.76	0.95	1.27
90.98 msw (297 fsw)	0.41	0.55	0.81	1.03	1.39
NEDU 5					
50.54 msw (165 fsw)	0.48	0.67	0.81	0.92	1.13
60.65 msw (198 fsw)	0.54	0.78	0.94	1.02	1.29
70.76 msw (231 fsw)	0.48	0.70	0.86	1.01	1.29
80.87 msw (264 fsw)	0.52	0.72	0.92	1.09	1.37
90.98 msw (297 fsw)	0.50	0.73	0.94	1.09	1.47